

## CLAIMS

1. A motion detector for detecting motion of a body in a surveillance zone comprising:  
at least one laser that produces laser light;

at least one photodetector that generates signals responsive to light incident thereon;

5 a light distributor that receives laser light from a laser of the at least one laser and distributes a portion of the light into a plurality of sensor light beams that extend into the surveillance zone and a portion of the light into at least one reference light beam that is incident on a region of the at least one photodetector, wherein the distributor is positioned and configured so that light reflected from a sensor beam by an object in the surveillance zone is  
10 received by the distributor and directed onto said region of the at least one photodetector; and circuitry that receives signals generated by the at least one photodetector and processes the signals to determine if reflected light incident on the at least one detector is Doppler shifted as a result of motion of the body, and if so, generates a signal indicating motion of the body.

2. A motion detector according to claim 1 wherein the at least one reference beam is formed by light that is back distributed by the distributor.

3. A motion detector according to claim 1 or claim 2 wherein the plurality of sensor beams is formed by light that is forward distributed by the distributor.

4. A motion detector according to any of the preceding claims wherein for each sensor beam of the plurality of sensor beams produced by the distributor the distributor produces a mirror image reference beam.

5. A motion detector according to any of claims 1-4 wherein the distributor comprises a surface on which light received from the at least one laser is incident, which surface has a partially reflecting layer that controls how much of the light from the at least one laser is distributed to the at least one reference beam and how much is distributed to the plurality of sensor beams.

6. A motion detector according to any of claims 1-5 wherein the distributor comprises a diffraction grating.

7. A motion detector for detecting motion of a body in a surveillance zone comprising:

at least one laser that produces laser light;

at least one photodetector that generates signals responsive to light incident thereon;

a light distributor comprising a diffractor that receives laser light from the at least one laser and distributes a portion of the light into at least one sensor light beam that extends into the surveillance zone and a portion of the light into at least one reference light beam that is incident on a region of the at least one photodetector, and the diffractor is positioned and configured so that light reflected from a sensor beam by an object in the surveillance zone is received by the light distributor, and distributed onto said region of the at least one photodetector;

circuitry that receives signals generated by the at least one photodetector and processes the signals to determine if reflected light incident on the at least one detector is Doppler shifted as a result of motion of the body, and if so, generates a signal indicating motion of the body.

8. A motion detector according to any of claims 7 wherein the at least one sensor beam comprises a plurality of sensor beams.

9. A motion detector according to any of claims 1-6, or claim 8 wherein the plurality of sensor beams comprises at least three sensor beams and at least three of the sensor beams are coplanar.

10. A motion detector according to any of claims 1-6, or claim 8 or 9 wherein the plurality of sensor beams comprises at least three sensor beams and at least one of the plurality of sensor beams is not coplanar with at least two of the other sensor beams.

11. A motion detector according to any of claims 1-10 wherein the at least one reference beam comprises a plurality of reference beams.

12. A motion detector according to claim 11 wherein the at least one photodetector comprises a plurality of photodetectors.

13. A motion detector according to claim 12 wherein a different one of the plurality of reference beams is incident on each photodetector.

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14. A motion detector according to any of claims 1-10 wherein the at least one photodetector is a single photodetector.

5 15. A motion detector according to any of claims 1-14 and comprising a motor or actuator that cyclically moves the light distributor back and forth in a given direction so that frequency of light in the at least one reference beam is shifted by a predetermined frequency shift.

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10 16. A motion detector according to any of claims 1-14 comprising an optical frequency shifter through which light reflected from the body passes, which optical frequency shifter generates a predetermined frequency shift in the frequency of the reflected light.

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15 17. A motion detector according to claim 15 or claim 16 wherein the predetermined frequency shift is greater than an expected Doppler shift of the reflected light caused by motion of the body.

20 18. A motion detector according to claim 17 wherein the circuitry processes signals from the at least one photodetector to determine a frequency difference between the frequency of a reference beam of the at least one reference beam and the frequency of the reflected light and determines that a component of motion of the body that generates the Doppler shift is in a first direction if the frequency difference is greater than the predetermined difference and in a second direction, opposite the first direction, if the frequency difference is less than the predetermined frequency difference.

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25 19. A motion detector according to claim 12 or claim 13 and comprising a first and a second linear polarizer through which light is incident on a first and a second photodetector respectively of the plurality of photodetectors passes.

30 20. A motion detector according to claim 19 wherein directions of polarization axes of the first and second polarizers are not parallel.

21. A motion detector according to claim 20 wherein the polarization axes of the first polarizer is substantially orthogonal to the axes of polarization of the second polarizer.

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22. A motion detector according to any of claims 19-21 wherein the reference beams that are incident on the first and second photodetectors are generated by the distributor from light from a same laser of the at least one laser, which laser provides linearly polarized light.

5 23. A motion detector according to claim 22 comprising a polarization detector that detects the direction of polarization of the light from the laser.

10 24. A motion detector according to claim 22 or claim 23 wherein an angle between the polarization direction of the first linear polarizer and the polarization direction of the laser light is substantially equal to 45°.

25. A motion detector according to any of claims 22-24 and comprising a circular polarizer that circularly polarizes the reflected light.

15 26. A motion detector according to any of claims 22-24 and comprising a circular polarizer that circularly polarizes light in the reference beams.

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20 27. A motion detector according to claim 25 or claim 26 wherein the first and second photodetectors respectively generate first and second signals responsive to reflected light and reference beam light incident on them, which first and second signals comprise, respectively, first and second signal components having a frequency equal to the Doppler frequency shift of the reflected light caused by motion of the body.

25 28. A motion detector according to any of claims 1-13 wherein a photodetector of the at least one photodetector is a polarization sensitive photodetector sensitive to light in first and second directions of polarization, which photodetector generates first and second signals that are substantially independent of each other responsive to intensity of light incident on the photodetector having a polarization direction parallel respectively to the first and second directions.

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29. A motion detector according to claim 28 and comprising a circular polarizer that circularly polarizes the reflected light.

30. A motion detector according to claim 28 and comprising a circular polarizer that circularly polarizes light in the reference beams.

31. A motion detector according to claim 29 or claim 30 wherein the polarization sensitive photodetector receives light from a single reference beam and reflected light from a sensor beam, both reference and sensor beams being generated by light from a same single laser of the at least one laser, and wherein the first and second signals have first and second signal components characterized by a frequency equal to a Doppler frequency shift of the reflected light caused by motion of the body.

32. A motion detector according to claim 27 or claim 31 wherein the circuitry determines which of the first and second signal components leads the other and if the first signal component leads the second signal component determines a first direction for a component of motion of the body that generates the Doppler shift and if the second signal component leads the first signal component determines a second direction for the component of motion which second direction is opposite the first direction.

33. A motion detector according to any of claims 1-32 wherein the at least one laser comprises a plurality of lasers.

34. A motion detector according to claim 33 wherein at least one of the lasers of the plurality of lasers provides light having a wavelength different from light provided by another laser of the plurality of lasers.

35. A motion detector according to any of claims 1-34 wherein light provided by a laser of the at least one laser is IR light.

36. A motion detector according to any of claims 1-35 and comprising at least one source of visible light, wherein when the at least one source is turned on, light from the source illuminates at least one region of the surveillance zone that is illuminated by light from a sensor beam of the at least one sensor beam.

37. A motion detector according to any of claims 1-36 wherein the at least one reference beam does not extend into the surveillance zone.

38. An intruder detection system for detecting presence of an intruder in a surveillance zone comprising a motion detector according to any of claims 1-37 wherein if the motion detector senses motion of a body in the surveillance zone, the circuitry determines if the Doppler shift is characteristic of motion of an intruder, and if it does generates a signal indicating presence of an intruder in the surveillance zone.

39. Apparatus for guarding an object against theft or damage comprising a motion detector according to any of claims 1-37 wherein at least one sensor beam of the motion detector is incident on the object and, if the object exhibits aberrant motion, generates an alarm.

40. Apparatus for monitoring health status of a person comprising a motion detector according to any of claims 1-37 wherein at least one sensor beam of the motion detector is incident on the person and, if the person exhibits aberrant motion, generates an alarm.

41. Apparatus according to claim 40 wherein the person is a baby and wherein a sensor beam of the motion detector is incident on the baby so as to detect breathing motions of the baby and if the breathing motions exhibit aberrance generates an alarm.

42. A method of detecting motion of an object in a surveillance zone comprising:  
diffracting light from a laser of at least one laser to generate at least one sensor beam of laser light that illuminates the surveillance zone;  
receiving light from a sensor beam of the at least one sensor beam that is reflected by the object; and  
determining whether the received light is Doppler shifted by a frequency generated by a component of motion of the object.

43. A method according to claim 42 wherein determining a Doppler shift comprises generating at least one reference light beam from light provided by the laser and determining whether the reflected light is Doppler shifted with respect to the light in a reference beam of the at least one reference beam.

44. A method according to claim 43 wherein generating at least one reference beam comprises diffracting light from the laser.

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45. A method according to claim 43 or ~~claim 44~~ wherein the at least one reference beam comprises a plurality of reference beams.

5 46. A method of detecting motion of an object in a surveillance zone comprising:  
generating at least one sensor beam of laser light from light provided by a laser that illuminates the surveillance zone;  
generating a plurality of reference beams of light from a portion of the light provided by the laser ;

10 receiving light from a sensor beam of the at least one sensor beam, which is generated from light from the laser, that is reflected by the object; and  
determining whether the reflected light is Doppler shifted with respect to light in each of the reference beams by a component of motion of the object.

15 47. A method according to any of claims 42-46 wherein determining a Doppler shift comprises:

coherently mixing the reflected light with light from at least one reference beam to generate at least one mixed signal; and

20 determining whether the at least one mixed signal comprises a signal component having a frequency equal to a Doppler frequency shift characteristic of a component of motion of the object.

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25 48. A method according to any of claims 42-47 and comprising introducing a predetermined offset frequency shift in the received light that is larger than an expected Doppler shift generated by a component of motion of the object, so that the received light has a difference in frequency with respect to the reference beam light that is equal to the sum of the offset frequency shift and the Doppler shift generated by the component of motion of the object.

30 49. A method according to any of claims 42-47 and comprising introducing a predetermined offset frequency shift in reference beam light that is larger than an expected Doppler shift generated by a component of motion of the object, so that a difference in frequency between the received light and the reference light is equal to the sum of the offset frequency shift and the Doppler shift generated by the component of motion of the object.

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50. A method according to claim 48 or claim 49 comprising determining a direction of the component of motion of the object that generates the Doppler shift responsive to whether the magnitude of the difference in frequency between the received light and the reference light is greater than or less than the offset frequency shift.

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51. A method according to claim 45 or claim 46 wherein light provided by the laser is linearly polarized and comprising circularly polarizing at least a portion of the reflected light.

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52. A method according to claim 51 and comprising linearly polarizing light in a first and second reference beam of the plurality of reference beams in first and second directions respectively.

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53. A method according to claim 52 and comprising linearly polarizing first and second portions of the circularly polarized reflected light in the first and second directions and coherently mixing the first and second portions of the reflected light with light in the first and second reference beams respectively so as to generate first and second mixed signals.

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54. A method according to claim 45 or claim 46 wherein light provided by the laser is linearly polarized and comprising circularly polarizing light in a first and a second reference beam of the plurality of reference beams.

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55. A method according to claim 54 and comprising linearly polarizing first and second portions of the reflected light in first and second directions respectively.

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56. A method according to claim 55 and comprising linearly polarizing the circularly polarized light in the first and second reference beams in the first and second directions respectively and coherently mixing the linearly polarized reference beam light with the first and second portions of the reflected light respectively so as to generate first and second mixed signals.

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57. A method according to claim 53 or claim 56 and comprising determining first and second signal components respectively of the first and second mixed signals that have a frequency equal to the Doppler shift of the received light.



58. A method according to claim 57 comprising determining a direction of the component of motion of the object that generates the Doppler shift responsive to which of the first and second signal components leads the other.

5 59. A method according to any of claims 42-47 wherein the laser provides linearly polarized light and comprising:

circularly polarizing light from the laser or the reflected light;

mixing the circularly polarized laser or reflected light with, respectively, the reflected or laser light that has not been circularly polarized;

10 generating first and second mixed signals responsive to mixed light in first and second polarization directions respectively;

determining first and second signal components respectively of the first and second mixed signals that have a frequency equal to the Doppler shift of the received light; and

15 determining a direction of the component of motion of the object that generates the Doppler shift responsive to which of the first and second signal components leads the other.

60. A method according to any of claims 51-59 and comprising detecting the direction of polarization of the linearly polarized light provided by the laser.

20 61. A method for determining presence of an intruder in a surveillance zone comprising detecting motion of the intruder according to any of claims 42-60.

25 62. A method for monitoring status of an object in a surveillance zone comprising detecting motion of the object according to any of claims 42-60 and if the object exhibits aberrant motion generating a signal indicating the occurrence of the aberrant motion.

63. A method for monitoring health and status of a person in a surveillance zone comprising detecting motion of the person according to any of claims 42-60 and, if the person exhibits aberrant motion, generating a signal indicating the occurrence of the aberrant motion.

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